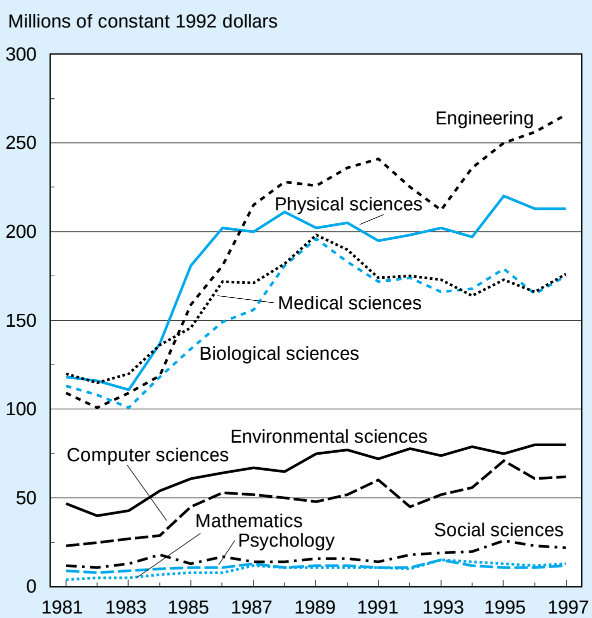
centrated in three fields: the life sciences (37 percent), engineering (23 percent), and the physical sciences (19 percent). (See figure 6-11.)

Current fund expenditures for academic research equipment grew at an average annual rate of 3.8 percent (in constant 1992 dollars) between 1981 and 1997. However, average annual growth was much higher during the 1980s (6.2 percent) than it was during the 1990s (0.7 percent). There were variations in growth patterns during this period among S&E fields. For example, equipment expenditures for mathematics (7.8 percent), the computer sciences (6.4 percent), and engineering (5.7 percent) grew more rapidly during the 1981–97 period than did those for the life sciences (2.2 percent) and psychology (2 percent). (See appendix table 6-16.)

Federal Funding. Federal funds for research equipment are generally received either as part of research grants—thus enabling the research to be performed—or as separate equipment grants, depending on the funding policies of the particular Federal agencies involved. The importance of Federal funding for research equipment varies by field. In 1997, the social sciences received slightly less than 40 percent of their research equipment funds from the Federal Government; in contrast, Federal support accounted for over 60 percent of equipment funding in the physical sciences, computer sciences, environmental sciences, and psychology.

The share of research equipment expenditures funded by the Federal Government declined from 63 percent to 59 percent between 1981 and 1997, although not steadily. This overall pattern masks different trends in individual S&E fields. For example, the share funded by the Federal Government actually rose during this period for both the computer and the environmental sciences. (See appendix table 6-17.)

Figure 6-11.
Current fund expenditures for research equipment at academic institutions, by field: 1981–97



NOTE: See appendix table 2-1 for GDP implicit price deflators used to convert current dollars to constant 1992 dollars.

See appendix table 6-16. *Science & Engineering Indicators – 2000*

R&D Equipment Intensity. R&D equipment intensity is the percentage of total annual R&D expenditures from current funds devoted to research equipment. This proportion was lower in 1997 (5 percent) than it was in 1981 (6 percent) and at its peak in 1986 (7 percent). (See appendix table 6-18.) R&D equipment intensity varies across S&E fields. It tends to be higher in the physical sciences and the computer sciences (both about 10 percent in 1997) and engineering (8 percent); and lower in the social sciences (2 percent), psychology (3 percent), and the life sciences (4 percent). For the social sciences and psychology, these differences may reflect the use of less equipment and/or less expensive equipment. For the life sciences, the lower R&D equipment intensity is more likely to reflect use of equipment that is too expensive to be purchased out of current funds and therefore must be purchased using capital funds. (See footnote 24.)

Academic Doctoral Scientists and Engineers

This section examines major trends over the 1973–97 period regarding the composition of the academic science and engineering (S&E) workforce, its primary activities (teaching vis-à-vis research), and the extent of its support by the Federal Government. For a discussion of the nature of the data used here, see sidebar, "Data Source."

The Academic Doctoral Science and Engineering Workforce[25]

Employment of science and engineering doctorates exceeded 60,000 by 1961[26] and reached 215,000 by 1973. Since 1973, the number has more than doubled, reaching 505,200 in 1997—a 135 percent increase. (See chapter 3, "Science and Engineering Workforce.") Over the 1973–97 period, the academic employment component increased from an estimated 118,000 to 232,500—a rise of 97 percent.[27] (See appendix table 6-19.) Consequently, the academic employment share declined over the period from an estimated 55 percent

[25]The academic doctoral science and engineering workforce includes full, associate, and assistant professors and instructors—defined throughout this section as faculty—lecturers, adjunct faculty, research and teaching associates, administrators, and postdoctorates.

[26]NSF (1964).

[27]The trend data in this section refer to scientists and engineers with doctorates from U.S. institutions, regardless of their citizenship status. Comparable long-term trend data for Ph.D.-level scientists and engineers with degrees from non-U.S. institutions are not available. A 1993 U.S. Department of Education survey of academic faculty suggests that this component of the academic workforce numbers around 13,000. An estimate derived from NSF's National Survey of College Graduates, based on the 1990 Census, puts the number at about 21,000. The higher estimate (which includes postdoctorates not necessarily covered by the Department of Education's survey) is likely to more closely reflect the definitions used in this chapter.

Data Source

The data used in this section to describe the employment characteristics and activities of academic doctoral scientists and engineers derive from the biennial sample Survey of Doctorate Recipients (SDR). SDR has been conducted since 1973 under the sponsorship of the National Science Foundation and several other Federal agencies. It underwent several changes in 1991 and again from 1993 forward which affect the comparability of data from these years with those of earlier periods.

Through 1989, the sample included three major respondent segments: (1) recipients of S&E doctorates from U.S. institutions; (2) a small number of holders of doctorates in other fields working in science or engineering in the survey year; and (3) a small number of persons with S&E doctorates from non-U.S. institutions. Starting with the 1991 sample, only recipients of S&E doctorates from U.S. universities were retained, and persons over 75 years old were ruled out of scope. Furthermore, sampling strata and sample size were reduced in an effort to improve response rates within budget constraints. Other changes in data collection included the introduction of computer-assisted telephone interviewing, which resulted in much higher response rates than had been attained previously.

A 31-month interval between the 1989 and 1991 surveys, instead of the usual 24 months, had substantive effects on the 1991 data: for example, a lower-than-average proportion of respondents in postdoctoral status, a higher-than-average proportion in faculty ranks. The interval between the 1991 and 1993 surveys was also nonstandard, 20 months.

Methodological studies to assess the full impact of these changes on overall estimates and individual data items are unavailable. Preliminary investigations suggest that SDR data permit analysis of rough trends, provided comparisons are limited to recipients of S&E doctorates from U.S. institutions. This has been done herein, with data structured in accordance with suggestions offered by the National Research Council's Office of Scientific and Engineering Personnel, which conducted these surveys through 1995. Nevertheless, the reader is warned that small statistical differences should be treated with caution.

The academic doctoral science and engineering workforce discussed in this chapter includes full, associate, and assistant professors and instructors—defined throughout this section as faculty—lecturers, adjunct faculty, research and teaching associates, administrators, and postdoctorates. Any discussion herein of status or trends of particular fields is based on the field of doctorate.

in 1973 to 46 percent of the doctoral science and engineering workforce in the 1990s, where it remains—close to its 1945–47 level.

Growth in academic employment over the past half century reflected both the need for teachers, driven by increasing enrollments, and an expanding research function, largely supported by Federal funds. The resulting relationship in academia of teaching and research, and the balance between them, remains the subject of intense concern and discussion[28] at the national level, as well as in academic institutions. Trends in indicators relating to research funding have been presented above. Below follow indicators reflecting the personnel dimension of these discussions: the relative balance between faculty and nonfaculty positions; demographic composition of the faculty; faculty age structure and hiring of new Ph.D.s; and trends in work responsibilities as reported by S&E Ph.D.s employed in academia.

A Long-Term Shift Toward Nonfaculty Employment Continued During the 1990s

Academic employment growth of science and engineering doctorates was quite low during much of the 1990s, from an estimated 206,700 in 1989 to 217,500 in 1995—an average annual increase of less than 1 percent. But by 1997, it had reached 232,500, reflecting a much stronger average rate of increase—3.4 percent annually—reminiscent of the growth rates registered during the 1980s. (See figure 6-12 and appendix table 6-19.)

Full-time doctoral S&E faculty—full, associate, and assistant professors plus instructors—participated in the 1995–97 increase. Their number, which had been roughly stable during the first half of the 1990s, rose strongly from 171,400 in 1995 to 178,400 in 1997. (See figure 6-12.) Nevertheless, the share of full-time faculty among all doctoral scientists and engineers with academic employment continued to decline. It reached an all-time low of 77 percent in 1997, from 88 percent in 1973; and 82 percent in 1989. (See appendix table 6-19.)

Thus, a long-term shift toward nonfaculty employment continued, as those in nonfaculty ranks—adjunct faculty, lecturers, research and teaching associates, administrators, and postdoctorates—increased from 36,900 in 1989 to 54,200 in 1997. The 47 percent increase for this group stood in sharp contrast to the 5 percent rise in the number of full-time faculty. Much of the rise in the nonfaculty segment was due to

[28] Some examples include *Presidential Directive for the Review of the Federal Government-University Partnership* (National Science and Technology Council 1999); *Challenges to Research Universities* (Noll 1998); "The American Academic Profession" (*Daedalus* 1997); *Science in the National Interest* (Clinton and Gore 1994); *Stresses on Research and Education at Colleges and Universities* (National Academy of Sciences 1994); *Renewing the Promise: Research-Intensive Universities and the Nation* (President's Council of Advisors on Science and Technology 1992); *Science and Technology in the Academic Enterprise: Status, Trends, and Issues* (National Academy of Sciences 1989); *Report of the White House Science Council: Panel on the Health of U.S. Colleges and Universities* (U.S. Office of Science and Technology Policy 1986).

Science and Public Policy (Steelman report)
Part One—Science for the Nation, III. Manpower: The Limiting Resource

Under present conditions, the ceiling on research and development activities is fixed by the availability of trained personnel, rather than the amounts of money available. The limiting resource at the moment is manpower.

…Those actually engaged in scientific research, technical development, and teaching comprise a much smaller group within this pool—about 137,000 persons today....But just as the share of the universities and colleges in the national research budget has been falling since 1930, so has their share in the trained manpower pool: from about 49 percent in 1930 to 41 percent in 1940 and 36 percent in 1947.

This is significant, because college and university scientists not only perform the major portion of basic research, but also because they teach. They are the source of further expansion in our pool of trained manpower. [Boldface in original]

There is a still smaller group within the 137,000 working scientists of which note should be taken: the 25,000 highly trained scientists with doctorates in the physical and biological sciences. As a general proposition,…[their number] provides a measure of the size of the group on which we rely for leadership in research, and for advanced teaching in the sciences.

[The table below, reproduced from volume four, shows the estimated distribution of doctoral scientists by sector for 1937–47.]

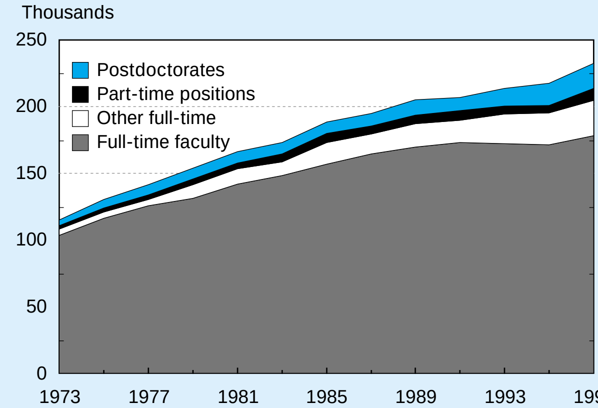
Year	Total	Colleges and universities	Industry	Government
1937	13,900	8,100	4,300	1,500
1945	23,200	10,000	10,000	3,200
1947	24,500	13,000	9,000	2,500

(Steelman 1947, 15.)

the growing use of postdoctorates.[29] Part-time employment—including faculty and other positions—accounted for between 2 and 4 percent of the total throughout. (See figure 6-12 and appendix table 6-19.)

This substantial shift during the 1990s toward nonfaculty employment touched most major fields. Except for computer sciences, continued growth in the nonfaculty segment was the rule. By 1997, full-time faculty percentages had dropped by as many as 10 percentage points (environmental sciences) since 1989 alone, with the other fields' declines falling into the 4–7 percentage points range. Over the entire period—1973 to 1997—the drops in the faculty share by field ranged from 8 to 18 percent. From 1989 to 1997, gains in the number

Figure 6-12.
Academic doctoral scientists and engineers by type of position: 1973–97



NOTE: Faculty includes full, associate and assistant professors plus instructors.

SOURCE: National Science Foundation, Division of Science Resources Studies, Survey of Doctorate Recipients, special tabulation.

See appendix table 6-19. *Science & Engineering Indicators – 2000*

of full-time faculty were largely confined to Ph.D.s in the life and computer sciences. For all other fields, their number remained essentially unchanged. (See appendix table 6-19.)

Research Universities' Employment Grew More Slowly Than That of Other Academic Institutions

The Nation's largest research-performing universities—Carnegie Research I and II institutions[30]—are widely regarded as a vital resource in U.S. science and engineering research and teaching. The number of doctoral scientists and engineers they employ rose steadily after 1973 but has essentially been static since 1989, at an estimated 113,600 in 1997. (See appendix table 6-20.) In contrast, employment at other institutions has grown uninterruptedly, especially after 1995. Since 1989, the research universities experienced a 6 percent decline in the number of their full-time doctoral S&E faculty, which was roughly offset by a 24 percent increase in nonfaculty personnel. Over the same period, other institutions' doctoral S&E employment expanded by 26 percent, with faculty rising by 7 percent and nonfaculty appointments more than doubling.

Behind these trends lie very different hiring patterns practiced by these institutions, as illustrated by an examination of their hiring of cohorts of recent doctorates—defined as those with a doctorate awarded within the last three years. (See fig-

[29]For more information on this subject, see "Postdoctoral Appointments" in chapters 3 and 4.

[30]Carnegie Classification Research I and II universities. This periodically revised classification describes research universities as institutions with a full range of baccalaureate programs, commitment to graduate education through the doctorate, annual award of at least 50 doctoral degrees, and receipt of Federal support of at least $15.5 million (average of 1989 to 1991). These criteria were met by 127 universities. (Carnegie Foundation for the Advancement of Teaching 1994).

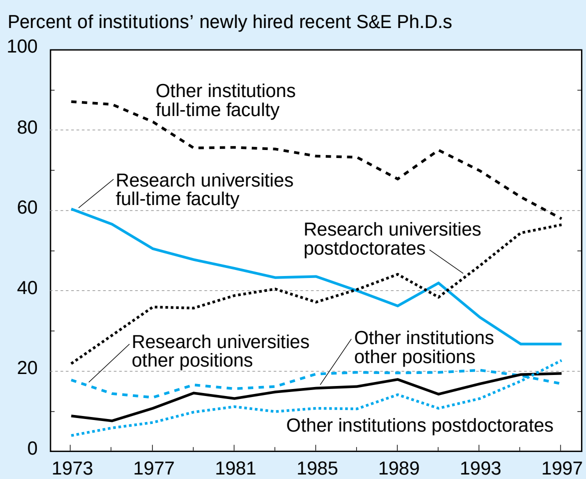
ure 6-13 and appendix table 6-21.) Except for the early 1970s, the research universities have consistently hired more recent Ph.D.s than all other universities and colleges combined. But their hiring has slowed in the 1990s, while that of the other institutions has increased. More telling is the distribution of these new hires by type of appointment. In recent years, fewer than 30 percent of recent doctorates hired by the research universities obtained a full-time faculty position—down from 60 percent in 1973. In contrast, almost 60 percent of those hired by other academic institutions received faculty appointments (compared to nearly 90 percent in 1973).

In the research universities, employment growth of S&E doctorates has largely been driven by those identifying research as their primary activity. (See appendix table 6-20.) Their number, 22,900 in 1973, had risen to an estimated 60,700 by 1997; their percentage among the research universities' doctoral S&E workforce rose from 35 to 53 percent. In contrast, the number of those for whom teaching was the primary activity rose from 32,300 in 1973 to a high of 39,200 in 1981 before declining to 33,400 in 1997—a decline from 50 to 29 percent of the total. Those identifying other functions as their primary work responsibility—including research management—grew from 9,200 to 19,600 over the period—staying well below 20 percent of the total for virtually the entire period.

In other types of universities and colleges, the number of doctoral scientists and engineers who identified research as their primary work activity grew from 4,900 in 1973 to 27,900 in 1997. Their share over the period rose from 9 to 23 percent, steeply increasing from the mid-1980s onward. The number of those for whom teaching was the primary work responsibility increased less rapidly, from 41,000 in 1973 to 72,000 in 1997. (See appendix table 6-20.)

Employment patterns also differed among full-time doctoral S&E faculty. At the research universities, full-time faculty overall fell by 6 percent between 1989 and 1997, with those reporting primary responsibility for research declining by 3 percent, and those with primary teaching responsibility by 9 percent. Developments were different in the other institutions, where full-time faculty rose by 7 percent over the same period, largely reflecting an increase of 4,300—40 percent—among those with primary research responsibility.

Figure 6-13.
Recent S&E Ph.D.s hired by research universities and other academic institutions, by type of institution and appointment: 1973–97



NOTES: Recent Ph.D.s have earned their doctorates in the three years preceding the survey year. Faculty includes full, associate, and assistant professors plus instructors. "Other positions" include part-time, research associate, adjunct, and other types of appointments outside the faculty track. Research universities are Carnegie Research I and II institutions.

SOURCE: National Science Foundation, Division of Science Resources Studies, Survey of Doctorate Recipients, special tabulations.

See appendix table 6-21. *Science & Engineering Indicators – 2000*

Women Are Increasingly Prominent in Academic S&E, but Not in All Fields[31]

The academic employment of women with a doctorate in science or engineering has risen dramatically over the past quarter century, reflecting the steady increase in the proportion of S&E doctorates earned by women. Since 1973, when this type of employment information was first collected, the number of women has increased more than fivefold, from 10,700 to an estimated 59,200 in 1997. Their proportion of the doctoral academic S&E workforce has increased from 9 to 25 percent over the period. (See appendix table 6-22.)

A similar rapid growth was registered in the number of women in full-time faculty positions.[32] (See figure 6-14.) However, even with this strong growth, their proportion of full-time faculty continues to lag their share of Ph.D. degrees. This underscores the long time lag involved in changing the composition of a large employment pool—in this instance, the academic faculty. Women represented 7 percent of the full-time doctoral academic S&E faculty in 1973. The effect of a growing proportion of doctorates earned by women, bolstered by their somewhat greater likelihood of choosing early academic careers, had pushed this proportion to 22 percent by 1997. By rank, they represented 12 percent of full professors, 25 percent of associate professors, and 37 percent of the junior faculty—the latter approximately in line with their recent share of Ph.D.s earned. (See appendix table 6-22.)

Among full-time doctoral S&E faculty, the number of men declines as one moves from senior ranks—full and associate professors—to junior-faculty ranks—assistant professors and instructors. In contrast, the distribution of women is inverted: more women hold junior faculty positions than are associate professors, and more are the latter than are full professors. This pattern is indicative of the recent arrival of significant

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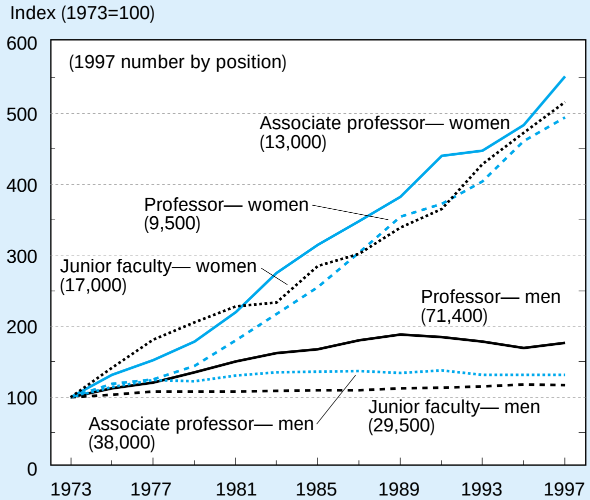
[31]Also see "Women Scientists and Engineers" in chapter 3 and "New Ph.D.s Enter Academia, but the Nature of Their Appointments Has Changed" later in this chapter.

[32]These numbers differ from those published in *Women, Minorities, and Persons with Disabilities in Science and Engineering: 1998* (NSF 1999k). That report's tables 5-9 through 5-12 show data on employment in four-year colleges and universities only, excluding faculty in other types of academic institutions, such as medical schools, two-year colleges, and specialized colleges. All of the latter are included here.

Figure 6-14.
Index of growth in full-time doctoral science and engineering faculty, by rank and sex: 1973–97



NOTES: Junior faculty includes assistant professors and instructors. Postdoctorate, nonfaculty, and part-time positions are not shown.

See appendix table 6-22. *Science & Engineering Indicators – 2000*

numbers of women doctorates in full-time academic faculty positions. It indicates that the trend toward increasing numbers of women among the faculty will continue—assuming that women stay in academic positions at an equal or higher rate than men—but also, that this process will continue to unfold slowly.

Since 1973, when these data on doctoral scientists and engineers were first collected, women in academic employment have been heavily concentrated in a few fields. Fully 84 percent of women scientists and engineers in 1997 had earned their doctorates in three broad fields: life sciences (42 percent), social sciences (22 percent), and psychology (20 percent); in contrast, only 58 percent of men were in these fields in 1997. Conversely, only 9 percent of women had degrees in the physical and environmental sciences in 1997—a steep decline from 14 percent of women in these fields in 1973—compared to 19 percent of men. Only 3 percent of all women had doctorates in engineering, versus 14 percent of men. (See appendix table 6-22.)

Concentration notwithstanding, when viewed over the entire 1973–97 period, women's doctoral field choices have undergone some changes. Among the academically employed, smaller proportions were found to hold doctorates in the physical and environmental sciences and mathematics in 1997 than in the early 1970s; these fields experienced a combined drop from 20 to 12 percent. Women's 37 percent life sciences share in 1973 rose to 42 percent in 1997, and larger percentages of women were also found with a Ph.D. in engineering and computer science by 1997. However, the proportion of women in academic employment with degrees in these latter fields remains very low. (See appendix table 6-22.)

Minorities See Large Growth Rates in Ph.D.s in Academic Employment, but Low Absolute Numbers[33]

The U.S. Bureau of the Census's demographic projections have long indicated an increasing prominence of minority groups among future college and working-age populations. With the exception of Asians and Pacific Islanders—who have been quite successful in earning science and engineering doctorates—these groups have tended to be less likely than the majority population to earn S&E degrees or work in S&E occupations. Private and governmental activities seek to broaden the opportunities of American Indians, Alaskan Natives, blacks, and Hispanics to enter these fields. Many target advanced scientific, engineering, and mathematics training, including doctoral-level work. What are the trends and status of these minority groups among S&E Ph.D.s employed in academia?

The story for these doctoral-level scientists and engineers is one of two trends, one dealing with rates of increase in hiring, the second with the slowly changing composition of the academic workforce. Rates of increase in employment have been remarkably steep. (See figure 6-15.) They far outpaced those for the majority population and have generally reflected the increased earning of science and engineering doctorates by minority group members.[34] However, a signal feature of these steep increases is the low bases from which they are calculated. As a result of the large majority population in the initial academic S&E doctoral pool,[35] American Indians, Alaskan Natives, blacks, and Hispanics remain a small minority in academia. Changing the structure of a large employment pool by changing the composition of the new participants requires a long time, unless the size of the inflow relative to the existing pool is large. (See appendix table 6-23.)

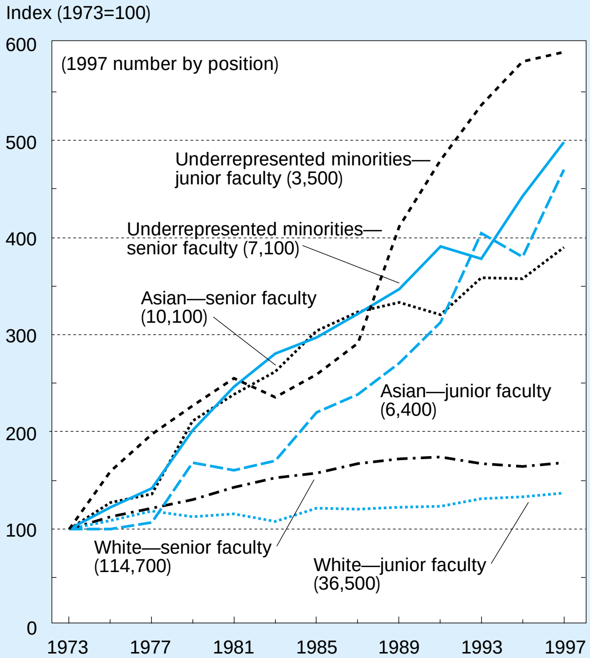
Academic employment of underrepresented minorities with S&E doctorates—American Indians, Alaskan Natives, blacks, and Hispanics—rose to 13,700 in 1997 from a mere 2,400 in 1973. Over this period, their employment share rose from 2 to 6 percent, approximately the same as their share of full-time faculty positions. By 1997, underrepresented minorities represented about 8 percent of the academic doctoral employment of those with degrees in psychology and the social sciences, 5–6 percent in the physical and life sciences, mathematics, and engineering, but only 3 percent in computer and environmental sciences. Their faculty percentages were quite similar. (See appendix table 6-23.) The overall field distribution of underrepresented minorities broadly parallels that of the majority population, with two exceptions. In 1997, underrepresented minorities were distinctly *less* likely than whites to possess Ph.D.s in the life sciences—

[33]Also see "Racial or Ethnic Minority Scientists and Engineers" in chapter 3 and "New Ph.D.s Enter Academia, but the Nature of Their Appointments Has Changed" later in this chapter.

[34]This in turn, of course, reflects their increasing participation in higher education and graduate school training. See chapter 4 sections, "Master's Degrees, by Race/Ethnicity" and "Doctoral Degrees, by Race/Ethnicity."

[35]Here measured from 1973 onward; data covering longer periods are not readily available.

Figure 6-15.
Index of growth in full-time doctoral science and engineering faculty, by rank and race/ethnicity: 1973–97



NOTES: Senior faculty includes full and associate professor; junior faculty includes ranks of assistant professor and instructor. Underrepresented minorities include American Indians, Alaskan Natives, blacks, and Hispanics.

SOURCE: National Science Foundation, Division of Science Resources Studies, Survey of Doctorate Recipients, various years, special tabulations.

See appendix table 6-23. *Science & Engineering Indicators – 2000*

28 versus 34 percent—and *more* likely to hold social sciences doctorates—26 versus 20 percent.

Asians and Pacific Islanders as a group have been quite successful in entering the academic doctoral workforce in science and engineering, as their number rose from 5,000 in 1973 to 25,400 in 1997. As a consequence of this rapid growth, their employment share nearly tripled, from 4 to 11 percent since 1973. In 1997, Asians and Pacific Islanders represented 27 percent of academically employed computer science Ph.D.s, 20 percent of engineers, and 14 percent of physical scientists and mathematicians. Their academic employment share among environmental and social science Ph.D.s, and especially psychologists, remained low—7 percent for the two former fields, less than 3 percent in the latter.[36] (See appendix table 6-23.)

Asian and Pacific Islander S&E doctorates in academic employment were much more concentrated in a few fields than other population groups. In 1997, 51 percent held degrees in the physical, environmental, and computer sciences; mathematics; or engineering—a much higher proportion than for whites (34 percent) or underrepresented minorities (28 percent). In part, this reflects the degree-taking choices of temporary visa-holders, who tend to favor engineering and mathematics-based sciences over less quantitative fields, and who often remain in the United States and gain academic employment. They have constituted more than half of the Asian and Pacific Islanders' total during the 1990s.

The Physical Sciences' Employment Share Declined; Life Sciences' Increased

The field composition of science and engineering Ph.D.s in academic employment over the 1973–97 period has been remarkably stable, with two notable exceptions: The academic employment share of Ph.D.s in the physical sciences declined from 19 to 13 percent, while that of doctorates in the life sciences rose slightly from 30 to 33 percent. Employment growth of physical sciences doctorates—rising 37 percent from 22,100 to 30,200—was much slower than that of other fields, which grew by a combined 107 percent overall; similar discrepancies were evident for growth in the full-time faculty segment. Both physics and chemistry shared this slow growth trajectory. In contrast, employment of Ph.D.s in the life sciences increased by more than 120 percent over the period, rising from 34,900 to 77,300. A large share of this gain reflected increases in the nonfaculty segment.[37] (See appendix table 6-19.)

The Average Age of the Academic S&E Faculty Continues to Increase

The rapid pace of hiring of young Ph.D.s into academic faculty positions during the 1960s to accommodate soaring enrollments, combined with slower hiring in later years, has resulted in a continuing increase in the average age of the U.S professorate. (See figure 6-16.) In 1973, 62 percent of the doctoral, full-time S&E faculty were under 45 years old, and only 13 percent were 55 or older. The under-45 group had shrunk to 50 percent by 1985 and constituted only 38 percent of the total in 1997. Those 55 or older were 21 percent of the total by 1985 and 26 percent in 1997. (See appendix table 6-24.)

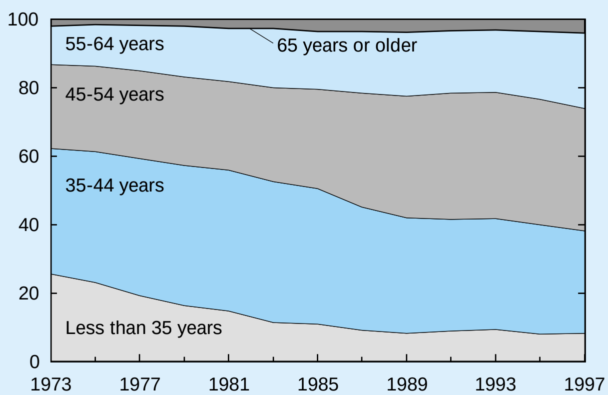
Starting in 1994, provisions of the Age Discrimination in Employment Act became fully applicable to universities and colleges; academic institutions could no longer require faculty to retire at a set age.[38] This development led to concerns about the potential ramifications of an aging professorate for universities' organizational vitality, institutional flexibility, and

[36]Pre-1985 estimates are unreliable because of the low number of computer science degree-holders in the sample.

[37]These trends may have been influenced by the relative field balances in academic R&D funds. See "Expenditures by Field and Funding Source" earlier in this chapter.

[38]A 1986 amendment to the Age Discrimination in Employment Act of 1967 prohibited mandatory retirement on the basis of age for almost all workers. Higher education institutions were granted an exemption through 1993, allowing termination of employees with unlimited tenure who had reached age 70.

Figure 6-16.
Age distribution of full-time doctoral science and engineering faculty: 1973–97



NOTE: Faculty includes full, associate, and assistant professors plus instructors.

See appendix table 6-24. *Science & Engineering Indicators – 2000*

financial health. These concerns were the focus of study by the National Research Council (NRC). The study concluded that "overall, only a small number of the nation's tenured faculty will continue working in their current positions past age 70" (NRC 1991, 29), but added: "At some research universities a high proportion of faculty would choose to remain employed past age 70 if allowed to do so" (NRC 1991, 38).

Data available now suggest that, for the system as a whole over the past decade, there has been little substantial change in terms of retirement behavior. Across all of higher education, about 3–4 percent of full-time faculty stays on beyond age 64, without any major changes over the past decade. As anticipated by the NRC study, on average, faculty at research universities tend to keep working somewhat longer than those elsewhere, but this has been the case for the entire 1973–97 period. The 1995–97 estimate of 4–5 percent for those older than 64 is in the estimated range for the entire past decade.[39] (See appendix table 6-25.)

It is also worth noting that research universities have managed to work toward a relatively more balanced age structure among their full-time faculty than is seen in other types of universities and colleges. (See figure 6-17.) The faculty age distribution in research universities tended to be older, on average, than that of other academic institutions through the early 1980s, but that tendency has since reversed. By 1997, research universities had a greater share of their full-time faculty in the under-45 age brackets than other institutions, and a slightly greater share in the above-59 brackets as well. (See appendix table 6-25.)

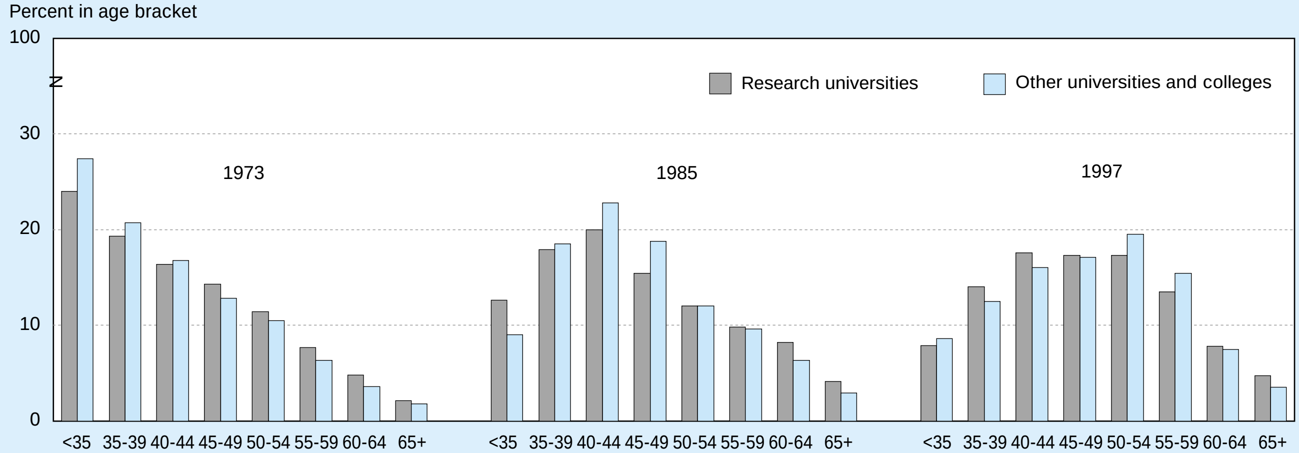
New Ph.D.s Enter Academia, but the Nature of Their Appointments Has Changed[40]

The hiring by universities and colleges of people with newly earned S&E doctorates provides a leading indicator of the composition of the future academic teaching and research workforce. However, the small number of new entrants rela-

[39]See also "Age and Retirement" in chapter 3.

[40]No trend data exist on detailed in- and outflows. The data reported here are "snapshots" of the number and demographic characteristics of doctorate-holders in academic employment who had earned their degree in the three years preceding the survey.

Figure 6-17.
Age distribution of full-time doctoral science and engineering faculty in research universities and other institutions: 1973, 1985, and 1997



NOTES: Faculty includes full, associate, and assistant professors and instructors. Research universities are defined by the Carnegie Corporation for the Advancement of Teaching by their program scope, Ph.D. production, and Federal funding volume.

See appendix table 6-25. *Science & Engineering Indicators – 2000* tive to the size of the existing academic employment pool ensures that coming changes will unfold gradually.

The number of recent S&E Ph.D.s—defined as those who had earned their doctorate in the three years preceding the survey year—who were hired into academic positions declined gradually from 25,000 in 1973 through the early 1980s, when it reached a low of 20,500. Starting in 1987, it rose again and reached 29,000 in 1997. These new entrants into academia represented approximately half of all recent S&E doctorate-holders entering U.S. employment. (See appendix table 6-26.)

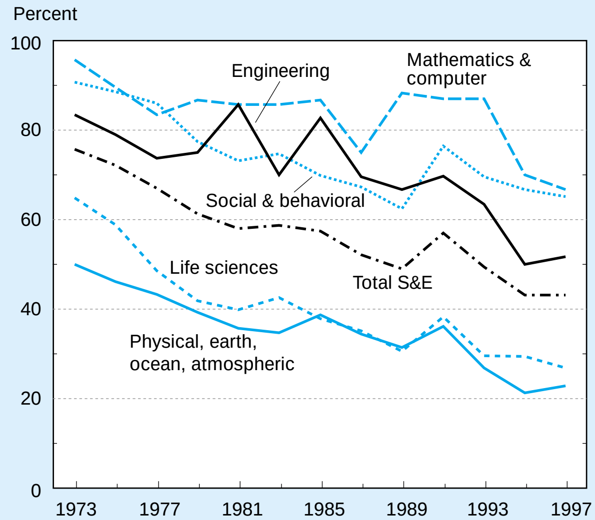
But the nature of academic employment for these young Ph.D.s has shifted considerably over this period. In 1997, only 41 percent reported full-time faculty appointments, compared with 76 percent in the early 1970s. Concurrently, the proportion holding postdoctorate positions increased steeply, rising from 13 percent to 41 percent;[41] other types of appointments have risen from 10 to 18 percent. (See appendix tables 6-26 and 6-27.)

The decline in the proportion of new S&E doctorate-holders with full-time faculty positions affected all fields. To some extent, these trends reflect the growing importance of early-career postdoctoral appointments in a number of fields; but the declines were also evident in those degree fields with relatively small numbers of postdoctorates. (See figure 6-18.) In the combined physical and environmental sciences, roughly one in five received a faculty appointment; in the life sciences, one in four. This compared with half or more than half of those with doctorates in engineering, mathematics and computer sciences, and social and behavioral sciences. (See appendix table 6-27.)

These changes have also affected the ability of recent S&E Ph.D.s hired into academia to enter the tenure track. While about three-quarters of all those hired into a *faculty* position were on the tenure track, few recent S&E doctorates received such an appointment. Overall, only one out of every three recent S&E doctorates hired into academia received such an offer.

The composition of these recent academic doctorate-holders has shifted noticeably over the more than two decades covered here, reflecting the changes in the population earning doctorates in science and engineering.[42] The proportion of women has risen from 12 to 39 percent. The proportion of underrepresented minorities has grown from 2 to 8 percent, of Asians and Pacific Islanders from 5 to 21 percent, and of non-citizens[43] from 8 to 27 percent. Similar trends are evident among those in full-time faculty positions, with these differences: Underrepresented minorities are somewhat better represented in the faculty segment than in overall employment, while Asian and Pacific Islander and non-citizen doctorate-holders are less well represented, especially since 1993. (See appendix table 6-26.)

Figure 6-18.
Percentage of academically employed recent S&E Ph.D.s with full-time faculty status, by major field group: 1973–97



NOTES: Recent Ph.D.s have earned their doctorate in the three years preceding the survey year. Faculty positions include full, associate, and assistant professor and instructor.

See appendix table 6-27. *Science & Engineering Indicators – 2000*

The field composition of these recent Ph.D.s reflects the larger employment changes. In 1997, 37 percent were in the life sciences (up from 28 percent in 1973), 12 percent were in the physical sciences (after dropping from 16 percent in 1973 to 10 percent in 1983), 6 percent were in mathematics (down from 9 percent in 1973), and 17 percent were in the social sciences (down from 23 percent in 1973). But their field distribution in full-time faculty and postdoctoral positions differs from this total employment picture, reflecting the fields' different propensities to hire new Ph.D.s into the faculty-track, as well as the general rise of postdoctoral appointments. Among postdoctorates, 54 percent were in the life sciences (compared to a life sciences share of 37 percent in total employment); 19 percent were in the physical sciences (versus a physical sciences share of 12 percent in total employment). Conversely, among those with faculty positions, 29 percent were in the social sciences, versus a 17 percent social sciences share of all recent academic S&E Ph.D.s. (See appendix table 6-27.)

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[41]An accurate count of postdoctorates is elusive, and the reported increase may be understated. A postdoctoral appointment is defined here as a temporary position awarded primarily for gaining additional training in research. The actual use of the term, however, varies among disciplines and sectors of employment. In academia, some universities appoint postdoctorates to junior faculty positions which carry fringe benefits; in others, the appointment may be as a research associate. Some postdoctorates may not regard themselves as genuinely "employed." Also see "Postdoctoral Appointments" in chapters 3 and 4.

[42]The consequences of these demographic trends in the hiring of recent Ph.D.s for the composition of the broader academic doctoral S&E workforce are discussed in earlier sections of this chapter dealing with women and minorities.

[43]Includes those in permanent and temporary visa status at time of doctorate.

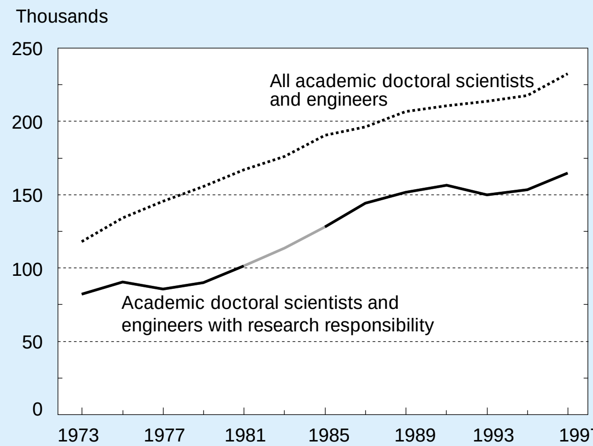
Research and Teaching Activities[44]

In academic settings, teaching, research, and research training are often inextricably intertwined. The conduct of academic research contributes to the production of new knowledge, educated students, and highly trained research personnel. Most academic scientists and engineers pursue teaching, research, and other duties in a mix that may change with the time of year and the course of their careers.

Participation in Academic Research and Development Is Once Again Increasing

U.S. universities and colleges are an indispensable resource in the U.S. R&D system, not only for their education and training functions: they conduct 12 percent of the Nation's total R&D, 27 percent of its basic and applied research, and 48 percent of its total basic research. (For more detail, see chapter 2.) A measure of the degree of faculty and staff participation in academic R&D can be constructed from S&E doctorate-holders' designation of one of four research functions[45] as a primary or secondary work responsibility. This yields a lower-bound estimate of the size of the academic doctoral research workforce broadly defined.[46] By this measure, in 1997 an estimated 164,700 academic doctoral scientists and engineers were engaged in some form of R&D,[47] up from a range of 80,000 to 90,000 during the 1970s. (See figure 6-19.) Between 1995 and 1997, the number of academic researchers, which had been essentially stable since the late 1980s following earlier robust growth, increased by 7 percent—by far its strongest increase in the decade. (See appendix table 6-28.)

Figure 6-19.
Total employed academic doctoral scientists and engineers and those with research responsibility: 1973–97



Note. Research responsibility is defined as reported primary or secondary responsibility for R&D. Numbers for 1981–85 are extrapolated: some respondents were not asked their secondary work responsibility (13, 7, and 13 percent, respectively).

SOURCE: National Science Foundation, Division of Science Resources Studies, Survey of Doctorate Recipients, special tabulation.

See appendix table 6-28. *Science & Engineering Indicators – 2000*

Approximately 71 percent of all academic doctoral scientists and engineers in 1997 were engaged in research or development activities, but this varied by field. At the high end—75 to 79 percent—were engineering, environmental sciences, and life sciences. Mathematics, psychology, and the social sciences reported the lowest levels of research activity, ranging from 59 to 66 percent. These field differences in the levels of research intensity have been fairly consistent over time.

The field composition of academic researchers has remained generally stable, with one exception: The relative employment shift noted earlier away from doctorates in the physical sciences and toward the life sciences is also evident in the research workforce. The share of physical science degree-holders among academic researchers (as defined here) has declined from 20 to 13 percent since 1973; that of the life science Ph.D.s has increased from 32 to 35 percent over the period. Other fields have experienced marginal gains or losses. (See appendix table 6-28.)

A rough indicator of the relative balance between teaching and research may be obtained by an examination of responses of academic doctoral scientists and engineers to a question about their primary work responsibility. The number of those reporting teaching as their primary work responsibility rose from 73,300 in 1973 to 101,000 in 1985 and fluctuated around the 100,000 mark before rising to 105,400 in 1997. In contrast, the number of those identifying research as their primary work responsibility increased without interruption from 27,800 in 1973 to 88,600 in 1997. (See appendix table 6-29.)

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[44]This material is based on individual respondents' reports of their primary and secondary work responsibilities. The data series—which is drawn from SDR—is reasonably consistent for the 1973–89 period: respondents were asked to designate primary and secondary work responsibilities from a list of items, the core majority of which remained unchanged. Since 1991, however, primary and secondary work responsibility has had to be inferred from reports of the activities on which respondents spent the most and the second-most amount of their average weekly work time. These two methods yield close—but not identical—results, so the SDR must be considered to produce a rough indicator only. In addition, some respondents in 1981–85 (13, 7, and 13 percent, respectively) were sent a shortened version of the questionnaire that did not ask about secondary work responsibility. For these respondents and these years, secondary work responsibility was estimated using full-form responses, based on field and type of position held.

[45]The choices, based on NSF's Survey of Doctorate Recipients, and for which definitions are provided, include basic and applied research, development, and the design of equipment, processes, structures, and models.

[46]The estimate fails to account for respondents who ranked research third or lower in their ordering of work responsibilities. Additionally, for 1981 through 1985, some respondents who received short forms of the survey questionnaire could not record a secondary work responsibility, thus resulting in a definite undercount for these years. All estimates are calculated based on individuals who provided valid responses to this item.

[47]An approximate 1993 estimate of the nondoctoral researcher component, excluding graduate research assistants, was derived from the U.S. Department of Education's National Survey of Postsecondary Faculty (NCES 1994). This component was estimated to be approximately 10 percent the size of the doctoral research workforce, and to be concentrated in the life sciences (75 percent) and engineering (10 percent). However, an estimate not restricted to that survey's definition of faculty, derived from SESTAT, NSF's data system on scientists and engineers, puts the number at about 21,000 (NSF 1999j).

In 1997, fewer than half of all respondents—45 percent—selected teaching as their primary work responsibility, a decline from 63 percent in 1973. While some of this decline is driven by the increasing number of postdoctorates on campus, a similar drop—from 69 to 53 percent—is observed for those in full-time faculty ranks. The increasing designation of research activities as primary work responsibility strongly suggests that the relative balance between teaching and research has shifted toward the latter, at least in the perception of these respondents. Those with other types of primary work responsibility—for administrative or managerial functions, service activities, and the like—constituted 13 to 19 percent of the total, and 11 to 17 percent among full-time faculty over the period, and thus have little influence on the apparent shift toward increased research emphasis. (See appendix table 6-30.)

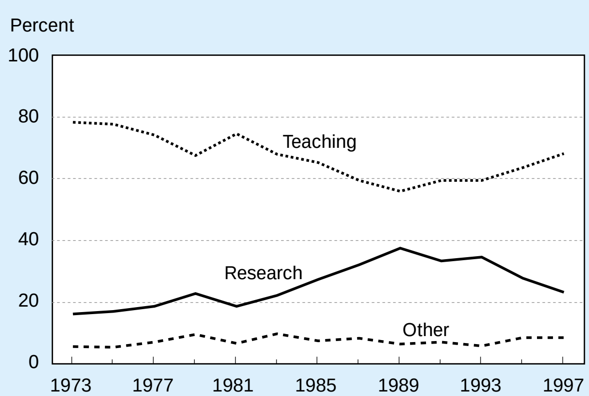
S&E doctorates in full-time faculty positions who earned their Ph.D. in the three years preceding the survey year show an interesting variation of this trend. From 1973 through the late 1980s, their percentage reporting teaching as primary responsibility declined from 78 to 56 percent, while that reporting research as primary rose from 16 to 38 percent. In the 1990s, these trends have reversed, with 68 percent choosing teaching and 23 percent designating research in 1997. (See figure 6-20 and appendix table 6-31.)

Federal Support of Academic Researchers

In 1997, 39 percent of the academic doctoral scientists and engineers reported receiving Federal funding for their research. (See appendix table 6-32.) This was in line with 1993 and 1995 findings, even as the number of academic researchers has expanded. These 1990s numbers reflect reports based on a question about the week of April 15 of the SDR survey year; those from earlier years (except 1985) were based on Federal support received over an entire year. If the volume of academic research activity is not uniform over the entire academic year, but varies to accommodate teaching and other activities, a one-week or one-month reference period will understate the number supported over an entire year.[48] Thus, the 1993–97 numbers (and 1985) cannot be compared directly to results for the earlier years. This earlier—1973–91—series indicates a decline in the proportion of federally supported researchers that coincided with stagnant real Federal R&D funds to academia during much of the 1970s (see chapter 2), followed by a rise in the proportion supported during the 1980s, especially during the latter half when Federal academic R&D funds again rose robustly.

Notable and persistent field differences exist in the proportion of researchers supported by Federal funds.[49] Above the overall S&E average are those with doctorates in the life, environmental, and physical sciences and engineering. Clearly below the mean are those in mathematics, psychology, and the social sciences. The relative position of these fields has not changed substantially over the past two decades. (See appendix table 6-32.)

Figure 6-20.
Distribution of primary work activity of recent S&E Ph.D.s in full-time academic faculty positions: 1973–97



NOTE: Recent Ph.D.s have earned their doctorate in the three years preceding the survey year.

See appendix table 6-31. *Science & Engineering Indicators – 2000*

Science and Public Policy (Steelman report)
Part One—Science for the Nation, I.
Science and the National Interest

Areas for United States Action

In light of the world situation and the position of science in this country, this report will urge:…

5. That a Federal program of assistance to undergraduate and graduate students in the sciences be developed as an integral part of an overall national scholarship and fellowship program. (Steelman 1947, 6.)

Financial Support for S&E Graduate Education

U.S. research universities have traditionally coupled advanced education with research—in the process providing scientific and engineering personnel as well as generating new knowledge. This integration of research and advanced training in S&E has served the country well as U.S. research universities attract graduate students from across the nation and the world. Upon receipt of their advanced degrees, these students set out to work in many sectors of the U.S. and other

[48]Indirect evidence that the extent of support is understated can be gleaned from the number of senior scientists and postdoctorates supported on NSF grants. This number is published annually as part of NSF's budget submission. It bears a relatively stable relationship to numbers derived from SDR in 1987, 1989, and 1991, but diverges sharply starting in 1993. (The figures from the two data sources are never identical, however, since NSF's numbers reflect those funded in a given fiscal year, while SDR numbers reflect those who have support from NSF regardless of when awarded.)

[49]The relative field shares of federally supported researchers appear to be stable across recent survey years, that is, they are relatively unaffected by changes in the survey reference period. The distribution (but not the estimated number) based on NSF estimates is quite similar.